Old concepts for New Times in photonics sensing: From Inconvenient to Practical

J.A. Martín-Pereda
ETS. Ingenieros Telecomunicación. Universidad Politecnica de Madrid
Ciudad Universitaria 28040 Madrid, Spain

Abstract – After a brief review of some old concepts getting application when new technologies have been developed, this paper offers a short review to some optical bistability concepts. It is shown how different concepts can be employed today in many fields, after being considered as inconvenient when they were found. Some practical applications and some proposals will be reported.

1 INTRODUCTION

Optical Bistability has been a very intensive field of research in the past thirty years. It got, in the middle of the eighties, a similar qualification than the laser twenty years before: *"a solution looking for a problem"*. After many tentative applications, covering from optical computing to image amplifiers – see, for instance, [1] – its main field of activity is now photonic switching and optical time-division mux and demux. But this area may be expanded if some of its previous disadvantages - as behaviour with strong dependence on external parameters - are taken as practical outputs. This fact opens the possibility of applying optical bistability in other areas as metrology and sensing.

2 PRELIMINAR CONSIDERATIONS

Although the first optical bistability analysis and studies were performed with devices working as individual non-linear elements with an external laser as optical radiation source, the main technological leap in this area came when the non-linear properties of active devices, as semiconductor lasers, got an adequate level to be easily employed. This situation has reached its zenith when devices as Vertical-Cavity Semiconductor Optical Amplifiers are almost conventional in any optical communication system. Their non-linear properties may be studied and employed with off the shelf components and their outputs are compatible with usual optical signals in many systems. This change was, as in any other field, due to the path from an unknown to a practical situation, from laboratory to the field. Moreover, this situation opens a new way in solving problems with some of the undesired previous behaviours.

It was a customary comment some years ago that optical bistable devices were too sensitive elements. Small changes in temperature, in the frequency of the impinging laser radiation, or in the signal level, affected drastically to the bistable output. In this way, an optical device could be bistable under certain conditions, but a very slight change in either internal or external parameters would affect to its properties. This situation was considered as a problem in the first years, but it can be seen now as a possible method for sensing a large number of external parameters.

3 ILLUSTRATIVE APPLICATIONS OF OPTICAL BISTABLE DEVICES IN MEASURING AND SENSING

As it has been shown, [2]-[4], the influence of different parameters in the working point of Fabry-Perot and Distributed Feedback Semiconductor Optical Amplifiers, as for instance, the initial phase detuning, the bias current or the top DBR period number, give rise to very different bistable characteristics at their outputs. Moreover, changes in the incident optical frequency, as small as 5 GHz, gives changes in the output light intensity as large as 200 μW; changes in input light linewidth of 50 pm give variations in the output intensity of 40 μW. These data may be complemented with several other cases.

From above considerations it is easy to point out that these devices are good candidates to be employed as sensing elements for detecting small variations in any optical radiation. These variations may be originated by the variation of different external conditions, either mechanical or electrical. The literature gives a large number of examples with this type of changes. In the case of Optical Bistability, these examples were indicated previously as the possible origin for an incorrect behaviour. They may be considered now as positive results.

4 CONCLUSIONS

The review of previous experiences from the past in any field may be a good source for new ideas trying to solve present day problems. It has been a normal practice just reading the latest published papers on a certain topic. Moreover, this reading focuses on the positive results achieved for particular products. But in some cases, reading negative results or failures for a certain application may give new ideas. And these new ideas are going to be based on those old concepts. No previous works have to be neglected and no just the latest results have to be considered.

5 REFERENCES

[1] P. W. Smith, "On the Physical Limits of Digital Optical Switching and Logic Elements", *Bell Syst. Tech. J.*, vol. 61, no. 8, pp. 1075-1993, 1982.

[2] A. Hurtado, A. Gonzalez-Marcos, J.A. Martin-Pereda, "Modeling Reflective Bistability in Vertical-Cavity Semiconductor Optical Amplifiers (VCSOAs)", *IEEE J. Quantum Electron.*, vol. 41, no. 3, pp. 376-383, 2005.

[3] A. Hurtado, A. Gonzalez-Marcos, J.A. Martin-Pereda, M.J. Adams, "Two-wavelength switching with a distributed-feedback semiconductor oprtical amplifier (DFBSOA)", *IEE Proc.-Optoelectron.*, vol. 153, no. 1, pp. 21-27, 2005.

[4] A. P. Gonzalez-Marcos, A. Hurtado, J.A. Martin-Pereda "Optical bistable devices as sensing elements" *SPIE* Vol. 5611, p. 63-70, Unmanned/Unattended Sensors and Sensor Networks; Edit.: Edward M. Carapezza. (2004)